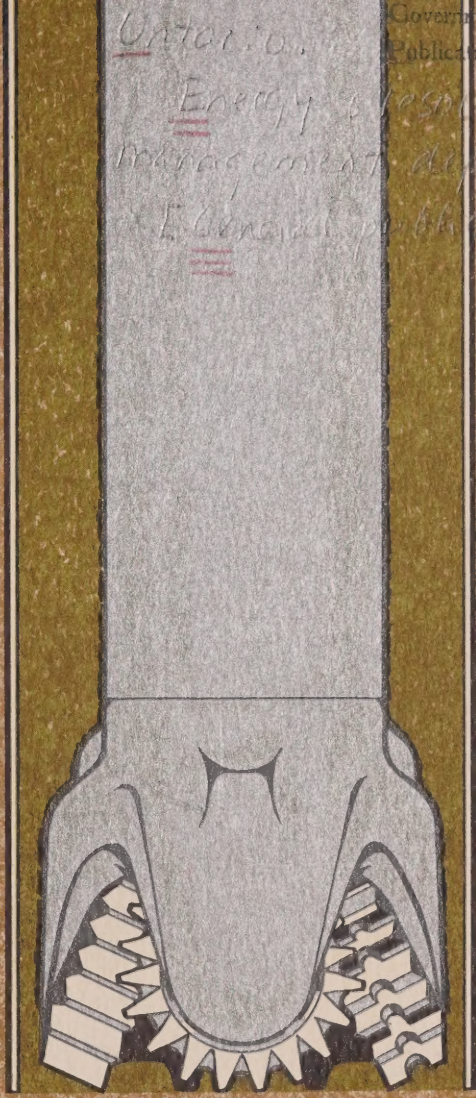


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IN ONTARIO

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OIL & GAS

IN ONTARIO

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Petroleum is the preferred fuel of the Twentieth Century and has become a necessity of our modern civilization. The value of its products exceeds that of any other mineral used by man and modern industry and transportation systems have become dependent upon it.

Ontario has long been a centre for the petroleum industry in Canada. In the mid-eighteen hundreds Ontario led the way in the development of Canada's petroleum resources and today, although a relatively minor producer of oil and gas, Ontario represents Canada's largest consumer market.

The following pages review Ontario's past, present and future in this industry and offer an insight into the processes and developments which have made the petroleum industry in Canada an exciting and important industry.



HISTORY

The North American petroleum industry was born in 1858 in Lambton County, Ontario, when James Miller Williams dug at the site of an oil seep and struck oil at sixty feet. The Williams' find was North America's first commercial oil well and touched off an oil boom that was not surpassed for ninety years.

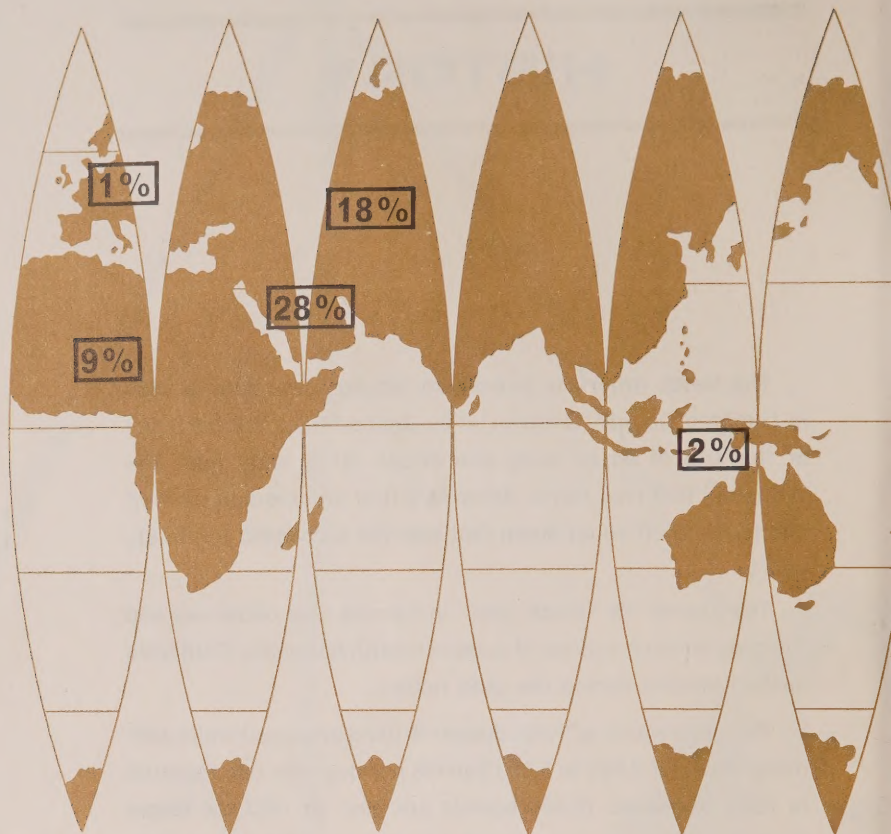
The search for "black gold" in Canada was underway and the area became a place of sudden wealth not unlike California or the Klondike during the gold rushes.

With increased activity, deeper drilling produced wells with initial flows of 2,000 to 5,000 barrels per day with one reported to have exceeded 10,000 barrels per day. In 1862 the larger Petrolia field was discovered and before 1900, more than 2,500 wells had been completed in an area of less than 20,000 acres.

During the first few years, the petroleum industry was mainly centered in the Oil Springs — Petrolia area. The remainder of Enniskillen Township, in the early 1860's, was still a virtual wilderness. The oil was transported by horse and wagon in wooden barrels over almost impassable mud roads, and often, the cost of transportation exceeded the price of oil at the well head. To overcome this, a wooden pipeline system from the Petrolia field to the nearby refineries was constructed in 1875.

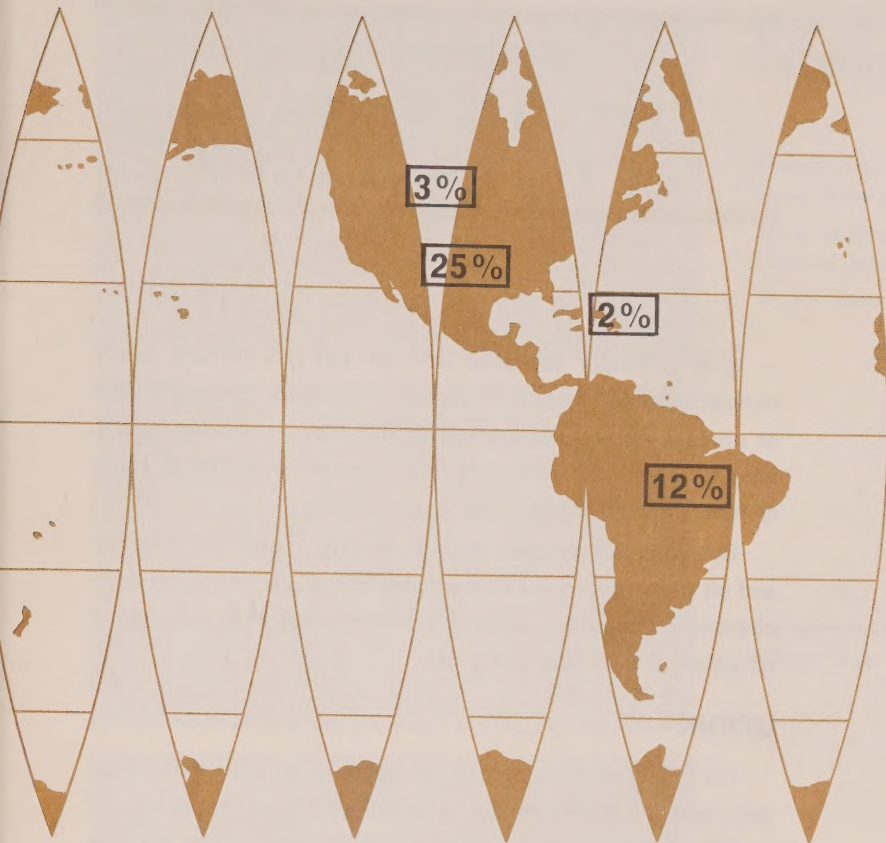
At the height of the early industry in 1873, annual output amounted to slightly more than 400,000 barrels of refined oil. The output consisted of an amber-coloured kerosene and gasoline which, at that time, was considered a dangerous and unsaleable item.

By 1885, new refining methods were introduced to remove



the fairly high sulphur content with the result that the price of oil increased. This price increase acted as an incentive for the industry and the search began for new fields — a search that has continued for eighty years.

Although natural gas was very often associated with oil, it was not until thirty years after the discovery of oil that gas was produced in commercial quantities. In 1889, the Coste No. 1 well was completed in Essex County near Leamington. The same year, six miles east of Port Colborne, Coste drilled a second successful exploratory well. These two fields, Kingsville and Welland, one at each end of the Southwestern Ontario Peninsula, were quickly developed and gas was soon being exported to Detroit, Toledo and Buffalo.



Total Production — 33 million barrels per day
Total Reserves — 389 billion barrels
Total Producing Wells — 750,000

Many more oil and gas fields in Ontario have since been discovered, developed and depleted. Some of the first producing fields such as Oil Springs and Petrolia still continue to operate but most of today's 90 producing fields were discovered during the last 25 years. More than 50,000 wells have been drilled in Ontario although only 1,200 are now producing oil and 2,200 gas. Reserves are estimated at 60 million barrels of oil and 800 billion cubic feet of gas. From these reserves, 45 million barrels of oil and 600 billion cubic feet of gas have been produced.

In 1966, Ontario production exceeded 1,300,000 barrels of oil and 15.5 billion cubic feet of gas, accounting for 0.4% of Canada's oil production and 1.1% of its gas production.

ORIGIN and OCCURRENCE of PETROLEUM

It is generally accepted that oil and gas formed when organic material, buried in marine muds, underwent changes to produce natural hydrocarbons. These hydrocarbons slowly moved into porous reservoir rocks and accumulated to form commercial oil and gas pools.

This complete process often took many thousands of years and oil occurrences are found today ranging from recent non-commercial deposits, several thousands years old, to ancient oil pools, 600 million years old.

ORIGIN

The slow, oxygen-free decomposition of the remains of plant and animal organisms is considered to be the source of petroleum hydrocarbons. The organic remains, which are rich in carbon and hydrogen — the building blocks of petroleum — accumulate in the bottom muds of lagoons and on the floor of shallow seas. These are then buried in accumulating sediments. Through bacterial action the organic material is slowly converted into petroleum.

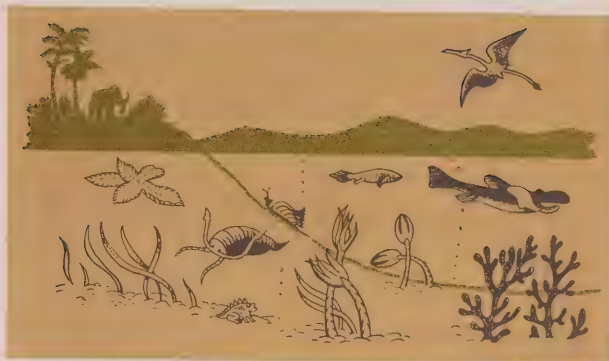
These processes have been taking place for many millions of years and with the passing of time the organic material and the newly formed droplets of oil were buried more deeply in the sediments. As covering sediments were deposited, the accumulating weight gradually compacted the lower beds and the enclosed fluids were squeezed out into places of less pressure such as pore spaces in sands.

OCCURRENCE

Droplets of petroleum accumulate only in porous or permeable rocks such as sandstones and porous or cavernous limestones. Oil may migrate with little or no accumulation

ORIGIN OF PETROLEUM

Many geologists believe simple forms of marine life in ancient seas were the source material for petroleum.



Sediments cover the remains of sea creatures.



Through the ages the sediments become thicker.



Pressure of sediments and other forces turn remains of sea creatures to oil and natural gas.



but only when concentrated accumulations occur are commercial oil or gas pools likely to result.

Oil will generally migrate upwards and will continue to migrate until it escapes at the surface or is arrested in some "trap" where it accumulates to form an oil pool. Such a trap is usually formed when an impervious caprock confines the oil in a reservoir rock.

Many different types of traps or structures have resulted in the accumulation of petroleum. The more important of these include anticlines, salt domes, faults, reefs and various other stratigraphic traps.

GEOLOGY of SOUTHWESTERN ONTARIO

Millions of years ago, the North American continent as we know it today had not yet been formed. There were no Rocky Mountains or Great Lakes but rather much of this land mass was covered by lush, green, almost tropical forests and ancient seas. Through the action of wind and water, a continuous process of erosion of the lands and deposition in the seas resulted. As the seas alternately advanced and retreated and the continent rose and was subsequently eroded, an eventual build up of sediments occurred.

Through geological processes of age determination and observances of rock characteristics, the many cycles which have occurred over the past 600 million years have been traced and recorded by geologists. Rocks formed during the older sedimentary cycles in Ontario are now referred to as Cambrian in age while more recent cycles classified by age include Ordovician, Silurian, Devonian, and Mississippian.

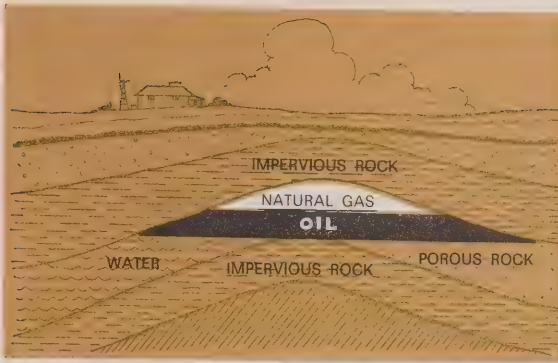
Since petroleum is known to occur in sedimentary rocks, the rocks of interest to the petroleum geologist are the lime-

THE PETROLEUM TRAP

THE DOME TRAP

Oil and gas is often found in folds in rock strata. Besides the dome type shown there are also anticlines and monocline folds.

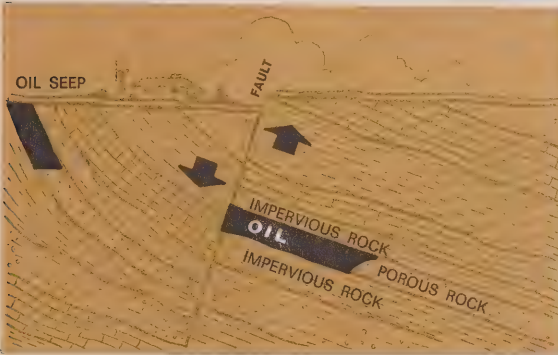
The petroleum found its way to reservoirs of porous rock which held it in much the same way as a sponge holds water. Some escaped to the surface but much is held in place by caps of impervious rock. Oil "floats" above the denser water, which is often salty. Gas, less dense than the oil, is present above the oil.



THE FAULT TRAP

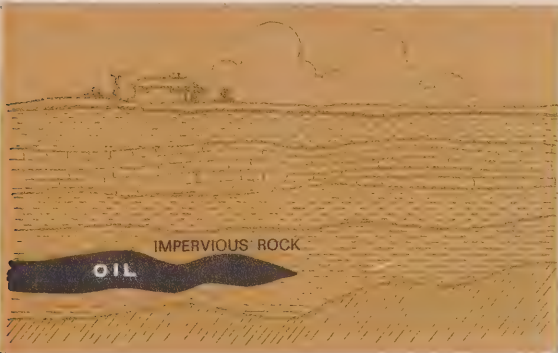
A fault is a split or crack in the earth's crust. When this crack occurs, movement generally takes place. If oil-bearing strata are present, oil which might otherwise have escaped to the surface is trapped by impervious rock present at the other side of the fault.

Faulting often occurs as a complicating factor in other forms of traps in Ontario Oilfields.



THE STRATIGRAPHIC TRAP

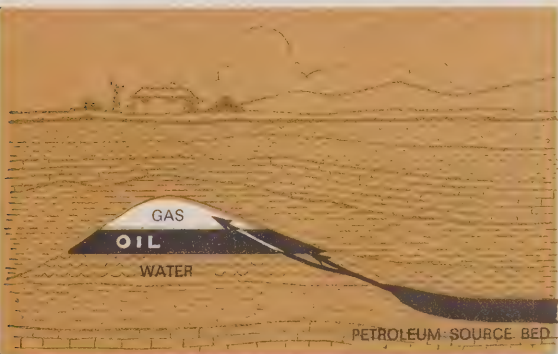
In this type the porous rock tapers off under the impervious capping rock. This may be due to it being the limit of the original sea or to the presence of an unconformity.



THE REEF TRAP

Coral reefs, which once approached the surface of ancient seas, form the basis of oil-bearing deposits. Plant and animal life was abundant in the seas around such reefs.

These reefs were later covered by deposits which now form impervious rocks and prevent upward seepage.





stones and sandstones which lie on top of the older Precambrian basement rocks. Although a much larger area of Ontario was once covered by a veneer of sedimentary rock, this was eroded, exposing the underlying Precambrian "granites", familiar to Muskoka residents. Those sedimentary rocks which do remain are restricted to three areas: the Hudson Bay Lowland, Eastern Ontario, and Southwestern Ontario.

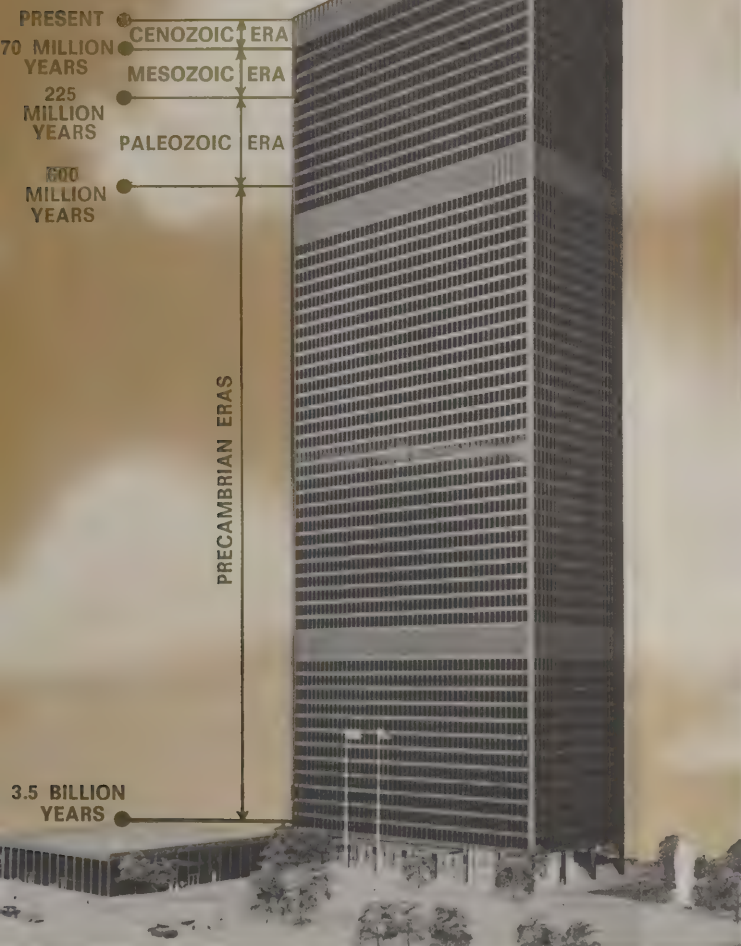
Although evidence of oil and natural gas has been found in most of the sedimentary rocks in Ontario, commercial production has been limited to Southwestern Ontario.

Unfortunately, most of the geology of Southwestern Ontario is concealed by a mantle of gravels and soils deposited during the Great Ice Age, which ended 10,000 years ago. However, the configuration of the subsurface has been generally

GEOLOGICAL TIME CHART

		Group or Formation	Rock Type	Depth Windsor-Sarnia Area	Date in Years From Beginning of Period	Succession of Life	1966 ONTARIO PRODUCTION	
Time Units							Oil	Gas
Cenozoic Era	Quarternary ABSENT		0'	1,000,000			
	Tertiary				70,000,000			
Mesozoic Era	Cretaceous				135,000,000			
	Jurassic				180,000,000			
	Triassic				225,000,000			
Paleozoic Era	Permian				270,000,000			
	Pennsylvanian				310,000,000			
	Mississippian	Port Lambton	Shale and Sandstone	90	350,000,000			
	Devonian	Kettle Point	Shale	100	400,000,000		46%	Nil
		Hamilton	Shaly Limestone	300				
		Dundee	Limestone	600				
		Detroit River	Dolomite	800				
		Bois Blanc	Sandy Dolomite	1100				
		Oriskany	Sandstone	—				
	Silurian	Bass Island	Dolomite	1300	440,000,000		26%	98%
		Salina	Salt, Shale, Dolomite Anhydrite	1400				
		Albermarle	Dolomite	2400				
		Clinton	Dolomite, Shale, Sandstone	2600				
		Cataract	Dolomite, Shale, Sandstone	2700				
	Ordovician	Queenston	Shale	2800	500,000,000		2%	less than 1%
Meaford-Dundas		Shale and Siltstone	3200					
Blue Mountain		Shale	3300					
Collingwood		Shale	3500					
Trenton-Black River		Limestone and Shaly Limestone	3700					
Cambrian	Eau Claire Mount Simon	Sandy Dolomite and Sandstone	4700	600,000,000	26%		less than 1%	
Precambrian			Igneous and Metamorphic	5500'	3,500,000,000			

THE GEOLOGICAL TIME SCALE COMPARED WITH THE TORONTO-DOMINION CENTRE, TORONTO, ONTARIO



determined and is known to consist of two sedimentary basins separated by a northeasterly trending Precambrian arch.

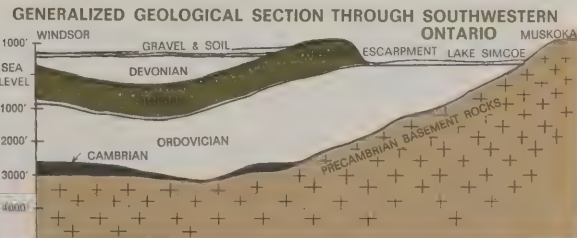
The sedimentary rocks in Southwestern Ontario, which are tilted or dip in a southwesterly direction, range in thickness from 0 feet north of Lake Simcoe and Kingston to over one mile at Sarnia.

The sedimentary rocks which occur in Ontario are relatively old since much of Ontario existed as a land mass after Mississippian time. As a result, the area was not covered by ancient seas and a build up of sediments did not occur. The youngest sedimentary rocks in Ontario are dated at 330 million years and the oldest at approximately 600 million years.

The major oil reserves of the Province occur in the Devonian sediments of Elgin and Lambton Counties. Because of the shallow depths of these fields — less than 500 feet — drilling and producing costs are kept at a minimum. The deeper Silurian and Cambrian oil occurrences — 2000 to 4500 feet — are becoming more important and now contribute more than one-half of the Province's total crude oil production.

Most of the Province's gas is produced from the Silurian pinnacle reefs in Lambton County and from the Silurian sandstones in both the Niagara Peninsula and the Lake Erie region.

Although the geology of Southwestern Ontario cannot be appreciated or fully understood by observing surface outcrops, much of what is available can be observed and studied along streams and rivers, in quarries, and along Ontario's most prominent erosional feature — the Niagara escarpment which trends in a northerly direction from the Niagara River to the Bruce Peninsula and Manitoulin Island.



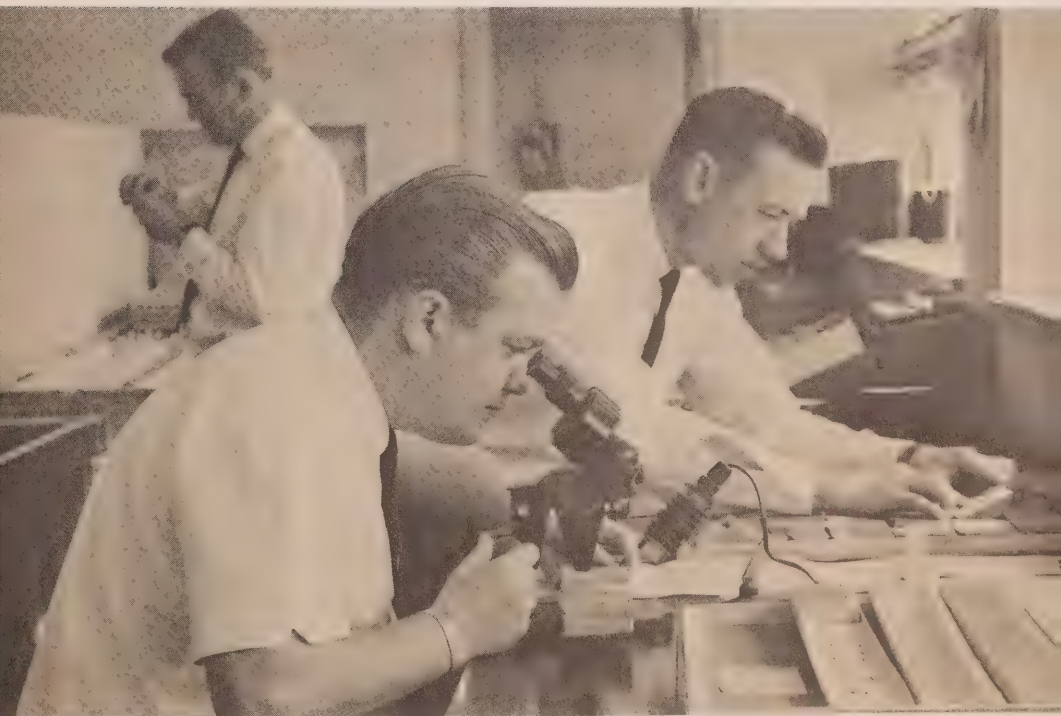
EXPLORATION DRILLING and PRODUCTION

EXPLORATION

By the very nature of the occurrence of oil and gas, if enough holes are drilled into the ground, discoveries will be made. Certainly this is very true of the stratigraphic traps in the Niagara Peninsula where thousands of wells have been drilled.

Various methods are used to locate oil and gas. Some discoveries are made by using what might be called "magic geology" based on folk lore or by using "doodle-buggers". The efficiency of these techniques is understandably low. When

Geologists
examining core



using the advanced techniques of geology and geophysics, the chances of discovering a producing well are much higher.

It is true that the only way to discover oil or gas is to drill, but the important concern of the geologist is to use all the techniques and tools available to him to predict the most likely location.

SURFACE GEOLOGY

The geologist begins his study by examining the rocks which appear or outcrop at the surface. His specialized training and knowledge enables him to predict from surface geological conditions the presence of favourable rock characteristics and structural features beneath the earth's surface. Once all the geological data is gathered for a particular prospect, the interpretive maps and cross-sections compiled by the surface geologist are correlated with the studies of the subsurface geologist.

SUBSURFACE GEOLOGY

In Ontario where the amount of outcrop is limited, the geologist must turn his attention to the rocks hundreds and thousands of feet beneath the surface. In studying the subsurface, the geologist relies mainly on information obtained from previously drilled wells. Examination of the drill cuttings and core provides the geologist with an accurate record of the underlying rocks. Through comparison and correlation of these drill cuttings, core samples and other available data with rock formations which are known to exist in other wells or areas, geological maps of the subsurface can be constructed.

The combined efforts of the surface and subsurface geologist are finally aided by the geophysicist.

GEOPHYSICAL PROSPECTING

While the geologist employs his scientific knowledge and methods in a direct manner to locate rock characteristics and subsurface structures which are considered favourable for the accumulation of oil and gas, the geophysicist works more indirectly. Geophysical prospecting searches for concealed deposits of hydrocarbons by measuring from the earth's surface the physical properties of materials within the earth.

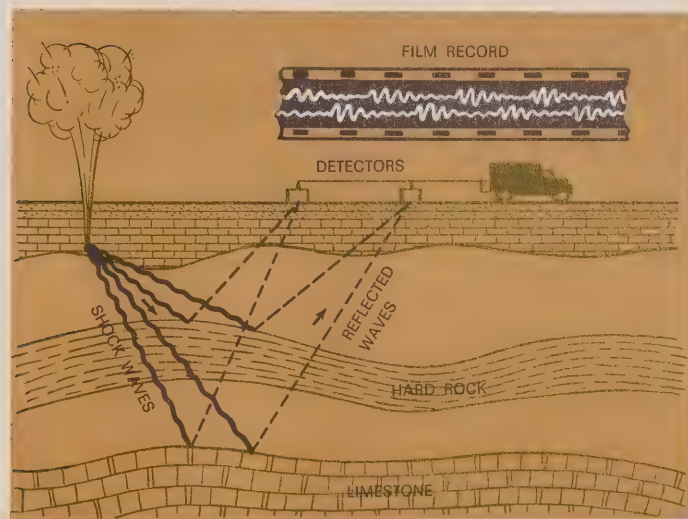
This information, when properly interpreted, can indicate positive structural areas wherein oil and gas may be entrapped if the rock characteristics are favourable.

The most common and perhaps the most valuable tool in geophysical exploration is the seismograph. The principle involved is similar to that used in measuring earthquakes. The shock waves are induced artificially by exploding a dynamite charge in a shallow drill hole which creates a pattern of shock waves thousands of feet into the subsurface. When sufficient contrasts exist between specific rock formations in the subsurface, shock waves will be reflected by the rock layers back to the surface. Geophones or microphone detectors placed on the surface record the time it takes for the energy to return and this data is instantly recorded at the site by a seismograph or onto magnetic tape.

Using a series of such surveys in a given area and knowing the speed that the sound travels through the different underlying rock formations, geological maps or cross-sections showing subsurface structure can be constructed.

Other common geophysical tools used are the magnetometer which measures the differences in magnetic intensity of the various rock formations and the gravimeter which measures the density of the underlying rocks. Any irregu-

REFLECTION SEISMOGRAPH TECHNIQUE



larities found by these methods are usually caused by structures within the sedimentary rocks or other features in the Precambrian basement rocks.

The success or failure in the exploration for oil or gas is largely dependent upon the co-ordinated skills and scientific knowledge of the geologist and geophysicist and their ability to utilize the techniques and exploratory tools available.

DRILLING

In many parts of the Province the oil and gas rights belong to the individual landowner. To facilitate the search for oil or gas on such properties, an oil or gas company leases the oil and gas rights from the landowner and, in return for this right to drill, gives to the landowner a percentage of any production, in the form of a cash royalty. Very seldom does an individual drill on his own property due to the speculative nature and high cost of such drilling.

Once a promising location or prospect has been selected, a drilling machine or "rig" is brought in to drill the well. There are two distinct methods of drilling oil and gas wells — cable tool and rotary. The cable tool is the older but for the most part has been replaced by the rotary method in most of the newer fields.

CABLE TOOL RIG

The cable tool system is essentially a process of repeatedly dropping a heavy tool that consists of a chisel-like bit suspended from a cable. The blows struck by the bit break off pieces of rock which are then periodically removed to allow further deepening of the hole.

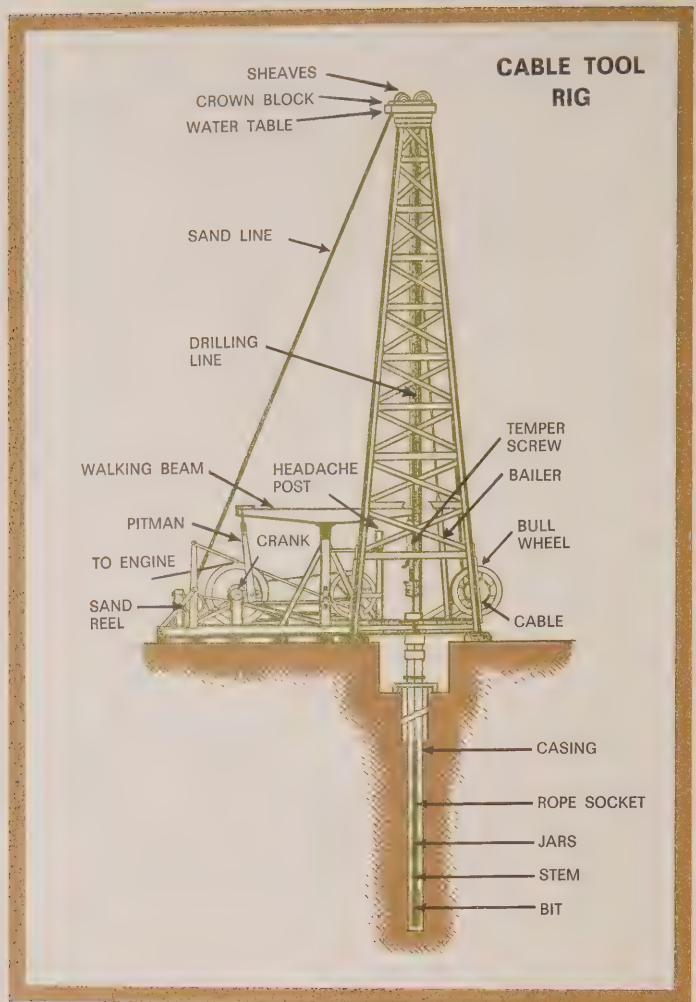
Cable tool equipment, although slower, costs less than the rotary machine, requires less manpower and is more economical for shallow drilling.

ROTARY RIG

The rotary rig consists of a derrick, sometimes exceeding 140 feet in height, hoisting mechanisms to lower and raise

**CABLE TOOL
RIG**

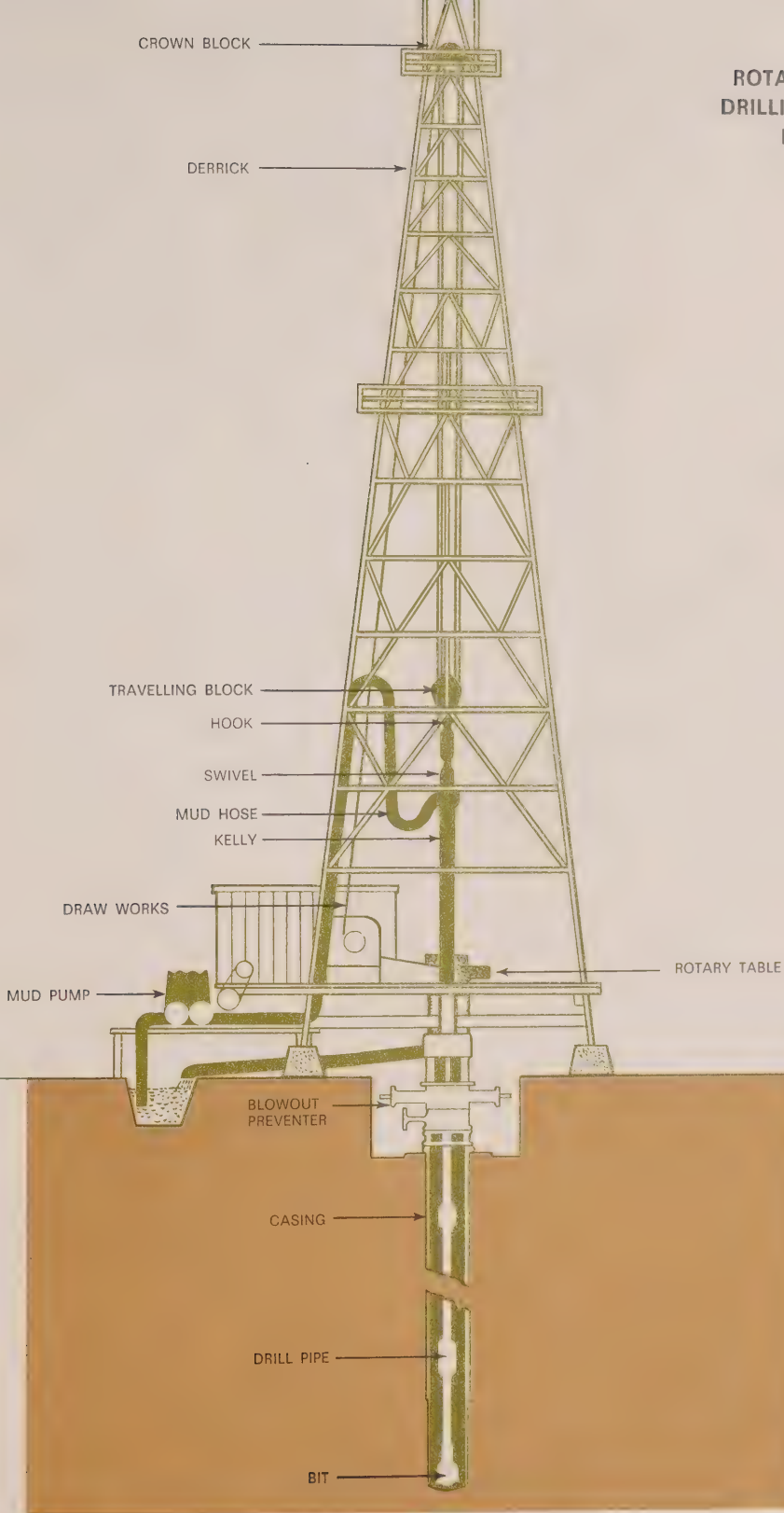




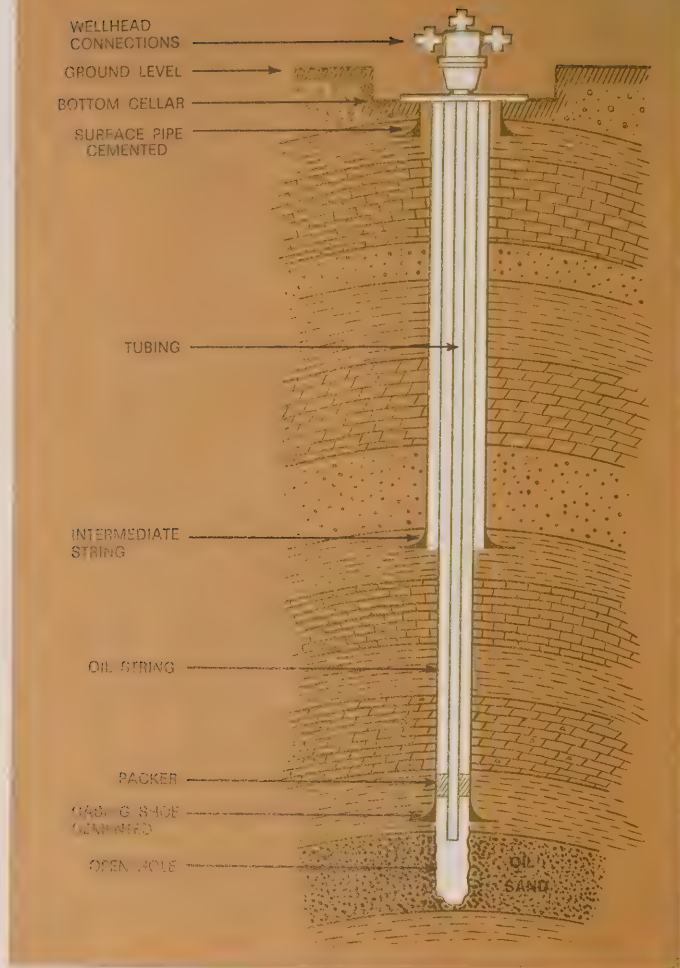
the drill pipe, and a turntable on the derrick floor which turns the drill pipe.

The turning of the drill pipe in the rotary method rotates a bit at the bottom of the hole, shaving and grinding off pieces of rock as it turns. The cuttings are removed by a continuous stream of drilling fluid or "mud" which is pumped down through the drill pipe, out an opening in the bit and back up to the surface between the drill pipe and the walls of the hole. In addition to lifting the drill cuttings to the surface, the drilling mud cools and lubricates the bit and plasters the wall of the bore hole with a stiff cake of mud, lessening the danger of a cave-in.

**ROTARY
DRILLING
RIG**



CASING A PRODUCING WELL



CASING

When drilling with both cable tool and rotary, a well is started with a relatively large hole; perhaps 12½ inches in diameter or larger. To prevent the mixing of fresh waters with sulphur and salt waters and to prevent loosely packed rock formations from caving into the hole, steel casing is inserted into the hole and is cemented in place or is attached to the wall of the well bore. Generally, several "strings" of casing are used in any one well and after each new casing is set in place, the normal drilling operations continue using a smaller diameter bit.



Offshore Drilling Platform

OFFSHORE OPERATIONS

Drilling for oil and gas in Ontario has not been restricted to land. The first offshore well drilled in North America was in Lake Erie, opposite the Township of Romney, during the summer of 1913. Although offshore operations had this early beginning, it was not until the 1940's that true offshore development began.

Since 1943, almost 500 offshore exploration and development wells have been drilled with 225 being completed as gas producers. These producing wells presently account for over 30 percent of the total gas production in the Province.

EXPLORATION

With only a very few islands in Lake Erie, the geologist must rely on subsurface geology and geophysical surveys to evaluate prospects in the lake. Existing lake wells provide detailed subsurface geological data although it is geophysical surveys which offer the broadest scope. The gravity meter has been used in the past and increasing interest in seismic techniques is evident. This interest may result in the entire Lake being covered by regional seismic surveys during 1968.

DRILLING

The drilling methods used offshore are basically the same as used on land except that a water-adapted drilling platform or barge is required. Several types of permanent and floating structures have been used for lake operations but at present the rotary drilling barge and the self-elevating barge are used most often. Drilling in Lake Erie is carried out primarily in waters shallower than 100 feet although wells have been drilled in water depths of 130 feet.

FORMATION EVALUATION

Drilling a well can be considered a means to an end — the location and efficient production of oil or gas.

Towards this end the geologist and the petroleum engineer must pay close attention to the rock formations penetrated in a well. The formations must be identified, any oil-bearing or gas-bearing zones located, and as much information as possible obtained about the reservoir rock in which such oil or



gas accumulations occur.

DRILL CUTTINGS

During most drilling operations, the geologist is usually at the well site 24 hours a day. He examines the drill cuttings under the microscope to determine the nature of the rock formations being penetrated and watches for tell-tale porosity or oil staining which may indicate a productive oil or gas zone. The examination of cuttings permits only a preliminary evaluation but often it enables the geologist to make a decision at the well site to use additional methods for obtaining more detailed information.

CORING

Where additional information is warranted, larger rock samples or “cores” can be obtained which allow laboratory examination of the physical properties of the rock such as porosity and permeability.

For this purpose, the rotary drilling bit is replaced by a “core barrel” which has a doughnut shaped “core bit” on the end. As drilling proceeds, a cylinder of the rock being cored passes through the hole in the core bit and is retained in the core barrel.

This is later brought to the surface and the core removed for detailed examination.



Cored section of a Silurian Reef showing vuggy porosity and fossils.

FORMATION TESTS

Although drill cuttings and coring will provide evidence of the presence of oil or gas, they will not yield information on the productive capacity of a potential oil or gas reservoir. For this purpose, a test must be run that will closely simulate the conditions of a producing well. The technique used is to isolate that part of the hole containing the possible oil or gas-bearing zone. A formation testing tool is lowered on the end of the drill pipe and rubber packers are expanded to seal off the potential zone. A direct connection between the surface and the zone is established and formation pressures and flows are obtained.

LOGGING

Once the drilling has been completed or at intervals during the drilling, it has become general practice to run some type of "log" or "logs" to obtain additional information on the rock type and the fluid content. Electric logs or radioactivity logs are obtained by running a logging tool into the hole and as the tool is raised, a continuous measurement is recorded on a graph at the surface. Using this information, the geologist is able to carry out sophisticated interpretations.

The benefits of a successful program of formation evaluation occur at every stage during the drilling of a well. Through the combined use of drill cuttings, cores, formation tests and logs, the geologist and petroleum engineer are able to scientifically evaluate potential reservoirs and determine if the well should be completed as a commercial producer.

COMPLETING AND PRODUCING A WELL

Where the data obtained from drill cuttings, core, logs and formation tests indicate the presence of a commercially productive oil or gas zone, the well is completed in a manner to permit the production of this oil or gas.

According to the nature of the producing zone, different completion methods are applied, but in each instance production casing is set down the entire length of the well and it is cemented on or near the bottom of the hole. To allow the oil

or gas to pass into the well-bore, the casing is then perforated.

The amount of oil or gas flowing into the well bore and being produced can often be increased by stimulating the well. Several stimulation methods may be applied but the two principal methods are "acidizing" and "fracturing".

When the productive zone is limestone and the rock has low permeability, or is "tight" resulting in few or restricted channels through which the oil or gas can flow, acidizing should improve the production.

The acid, pumped down the well under pressure, reacts with the limestone which dissolves like an aspirin in water.

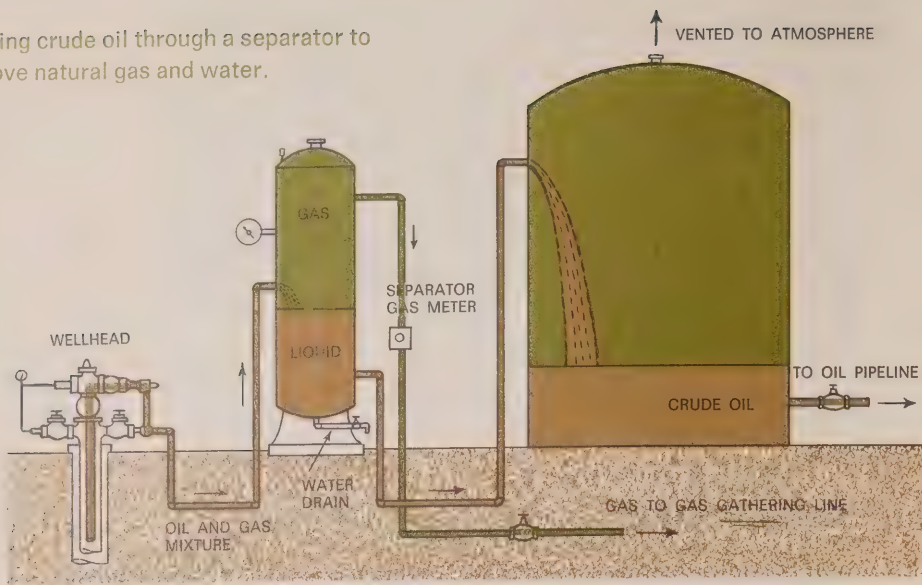
Fracturing can often provide improved productivity. By forcing sand grains in a fluid suspension under high pressure into the rock formation, the pressure literally lifts the formation, fractures it, and the sand grains upon entering these fractures, wedge them open.

This leaves the producing zone with greater permeability,

A pump jack
operating in an
oilfield in
Southwestern
Ontario



Passing crude oil through a separator to remove natural gas and water.



and enables the oil and gas to flow more readily into the well bore.

PRODUCTION METHODS

Petroleum reservoirs are subjected to widely varying pressures. In some reservoirs the dominant energy drive may result from a gas cap or from gas coming out of solution in the oil. The propulsive force in driving the oil into the well may also result from a natural water drive.

The surface installation or wellhead for flowing oil wells and for gas wells consists of a series of valves which control the flow of fluids or gas from the reservoir. Because of the numerous connections, valves and gauges which make up a wellhead it is often referred to as a "christmas tree".

Although a large quantity of oil is produced by flowing wells, insufficient pressures exist in the great majority of wells and these must be produced by mechanical pumping.

Once the oil is brought to the surface, the gas and water, which are often mixed with the oil, must be removed or separated. This is done by a separator at the well site before transportation to the pipeline or refinery. The gas collected at the separator may be processed for propane and butane, flared or returned to the reservoir through injection wells to maintain formation pressures.

CONSERVATION

In the early years of the petroleum industry, every owner of a property located in a producing area drilled as many wells as possible to prevent his property from being drained by his neighbour. This "law of capture" resulted in wells being drilled only a few feet apart and being produced at their maximum rate. Having little knowledge of good oil and gas conservation practices, the reservoirs were improperly drained and a large percentage of the original oil-in-place was left in the reservoir rock when the field was no longer commercially productive. In some of the older Ontario fields, such as Oil Springs and Petrolia, it is estimated that as much as 80 per cent of the oil was originally left in the reservoir.

In addition to the gross waste and inefficiencies of early production techniques, the excessive rates of production created economic chaos within the industry.

RESERVOIR MECHANICS

Much of the early waste of oil and gas stemmed from a general lack of appreciation and understanding of the occurrence of petroleum and the reservoir pressure mechanisms that provide energy to produce the oil. The importance of reservoir pressure to the oil producer cannot be overemphasized and must be understood if this energy is to be properly used to obtain maximum recovery of the oil in the reservoir.

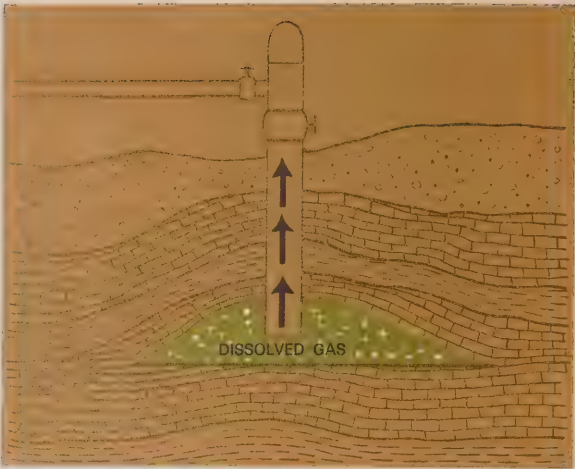
Petroleum is propelled out of the reservoir and into the well by one, or a combination of three processes: dissolved gas drive, gas cap drive, and water drive.

In dissolved gas drive, the propulsive force is the gas which is in solution in the oil and which tends to come out of solution as it expands into the area of reduced pressure at the well bore. As the gas moves into the well bore, oil is driven or carried with it.

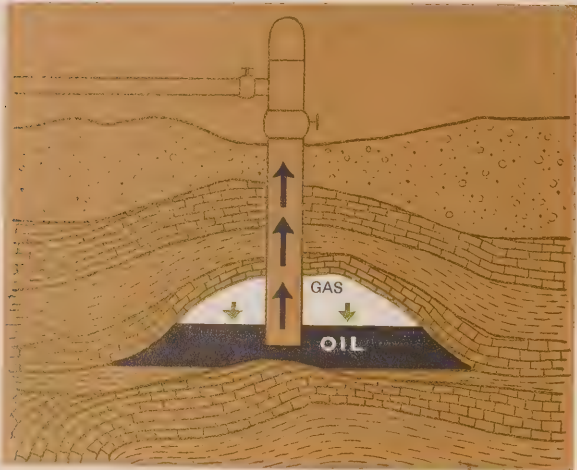
Where gas overlies the oil, beneath the top of the reservoir trap, the gas exerts a downward pressure on the oil and forces the oil into the well. By producing the oil below the gas cap and conserving the gas cap energy, as much as 70 to 80

**TYPES OF ENERGY
DRIVES FOUND IN
OIL FIELDS**

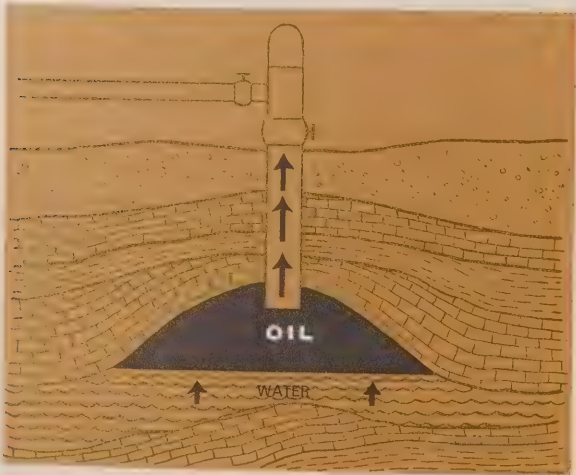
SOLUTION GAS DRIVE



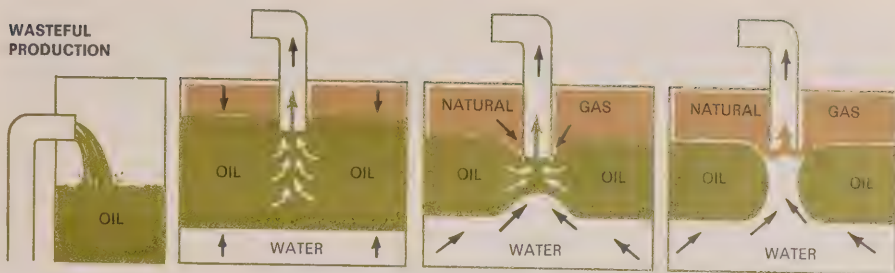
GAS CAP DRIVE



WATER DRIVE

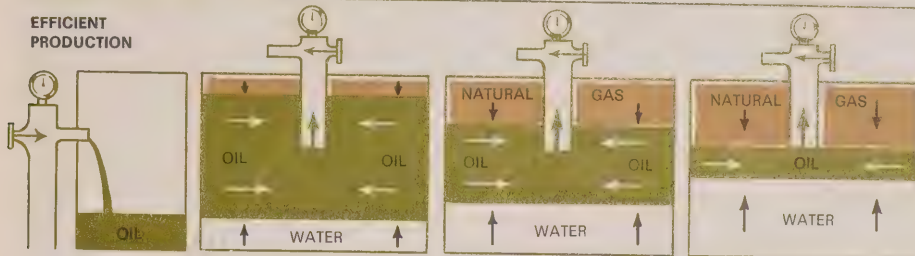


WASTEFUL PRODUCTION



Uncontrolled oil production is very wasteful.

EFFICIENT PRODUCTION



Restricting the flow increases ultimate yield.

CONTROLLING WASTEFUL PRODUCTION

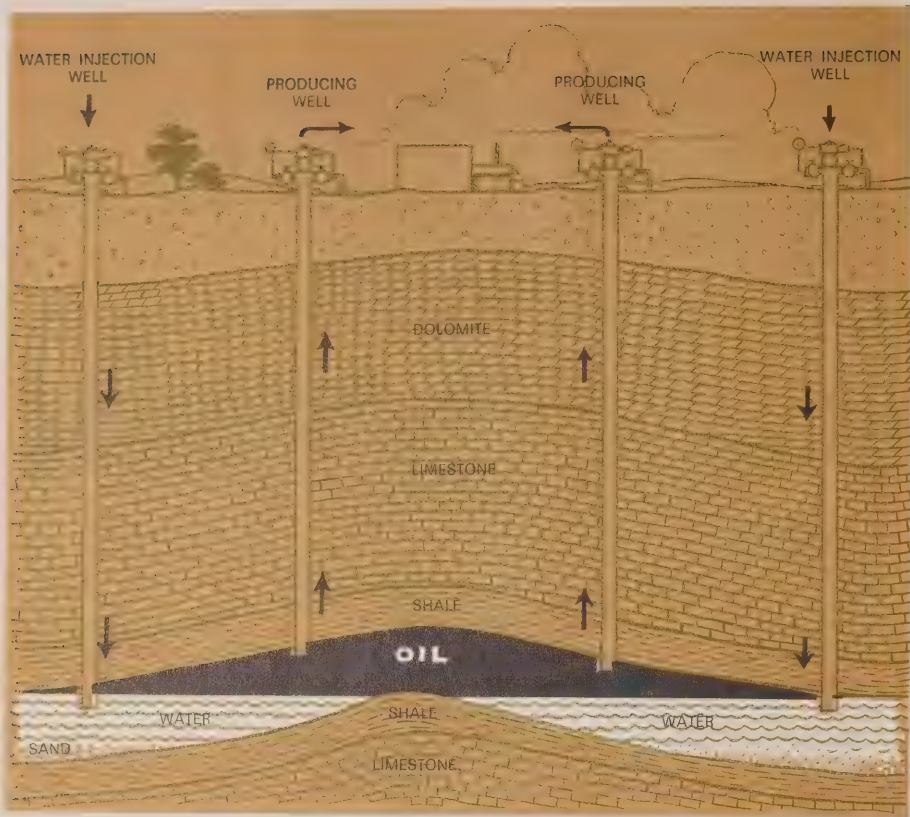
per cent of the oil can be recovered.

The most efficient propulsive force in driving oil into a well is a natural water drive, in which the pressure of the water forces the lighter oil ahead and upward until all the recoverable oil has been flushed out of the reservoir into the producing wells. Should, however, too rapid production occur, a sudden drop in pressure will often result and cause the underlying water to “cone” through the oil and damage channels through which the oil was moving.

If properly produced, a reservoir having a water drive will yield up to 80 per cent oil recovery.

SECONDARY RECOVERY

Various procedures have been devised for the purpose of extracting the oil left in the reservoir after a field has been depleted beyond commercial production. These are referred to as “secondary recovery” methods; the two methods most widely used being gas repressuring and water flooding. Although originally devised to stimulate or revive production as a field approached abandonment, these methods are now being introduced early in the life of a field to maintain the reservoir pressure.



SECONDARY RECOVERY OPERATION

Repressuring the oil formations by the injection of gas generally "rebuilds" the gas cap and recreates the gas cap energy which exerts a pressure upon the oil.

Water flooding has proven very successful and is generally regarded to be the most efficient method available. The water is injected under pressure into the producing formation and the oil is forced or flushed out of the reservoir through the producing wells.

Secondary recovery projects continue to increase in number in Ontario and are resulting in the stimulation of many fields nearing economic depletion.

Even as new fields are discovered each year, secondary recovery methods will continue to play a key role in the development of the Province's petroleum resources.

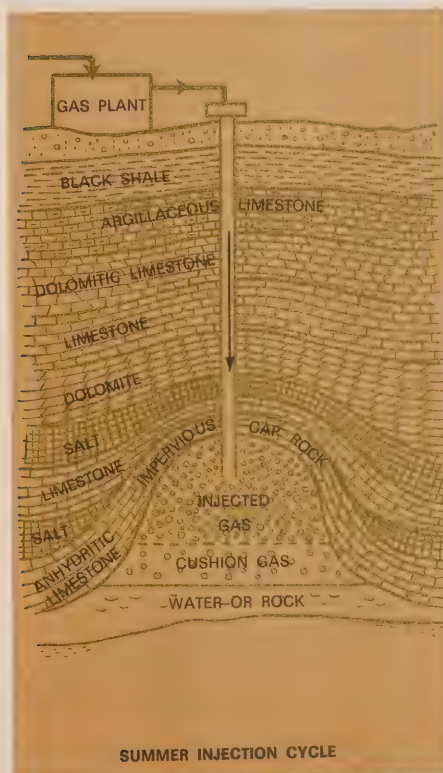
GAS STORAGE

During the early development of Ontario's gas industry, the market expansion outpaced the discovery and development of new reserves. This market expansion has continued until today, the gas produced in Ontario represents only 5 per cent of the 200 billion cubic feet consumed in the Province. As a result, most of our gas must be piped in from Western Canada and the United States.

Throughout the winter months, heavy demands are made on the pipeline facilities and a method of storing gas in the summer is necessary to ensure continuous delivery of gas to customers during peak periods. The most economical means

SCHEMATIC OF REEF GAS STORAGE SYSTEM

(Reef actually filled with gas at any pressure)



of storage has proven to be the underground storage of gas in abandoned mines, salt caverns, or various types of depleted gas pools.

In the early 1940's, Union Gas Company of Canada began importing gas in the summer and storing it for use in the winter months. With the introduction of natural gas from Western Canada in 1958, the importance of storage facilities in Ontario became even more evident and this importance has continued to grow until now there are thirteen storage reservoirs with a total working capacity of 121 billion cubic feet. Ontario's important gas storage reservoirs are located in Lambton County where depleted Silurian pinnacle reef gas pools provide natural reservoirs that can store large volumes of gas under high pressure.

Since it is most important to be able to supply sufficient gas from storage to satisfy the peak demands of the coldest winter days, a "cushion" of gas is used to maintain the high pressure. If too much cushion gas is produced the overall reservoir pressure decreases and destroys the effectiveness of a gas storage reservoir.

As Ontario's consumption of natural gas continues to rise, gas storage, both in Lambton County and in Eastern Ontario, will play a necessary and key role.

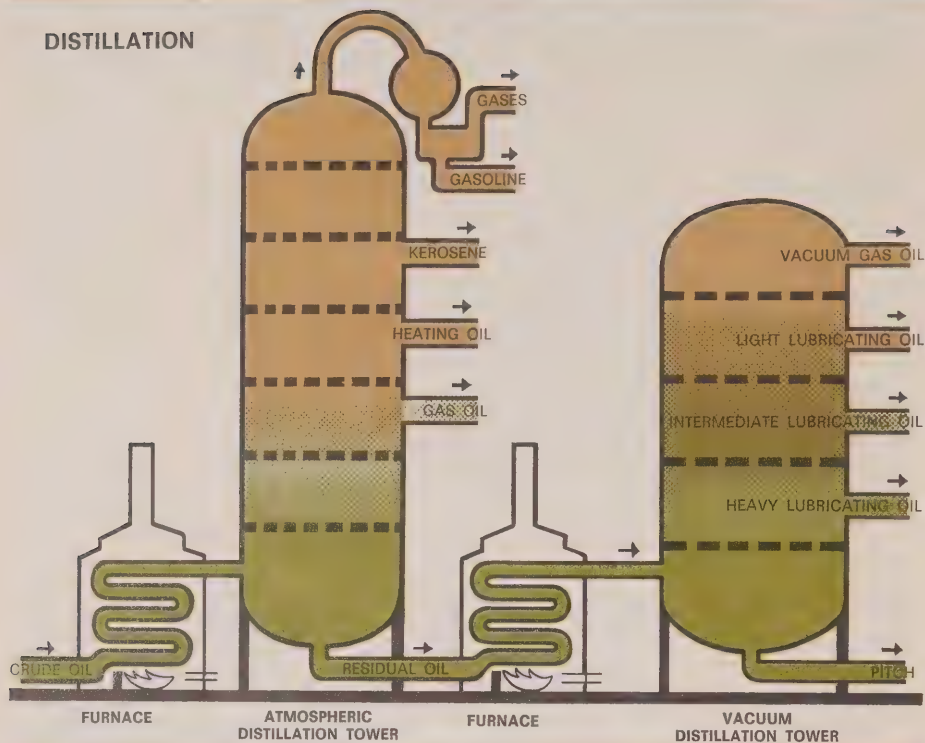
UTILIZATION

PIPELINES

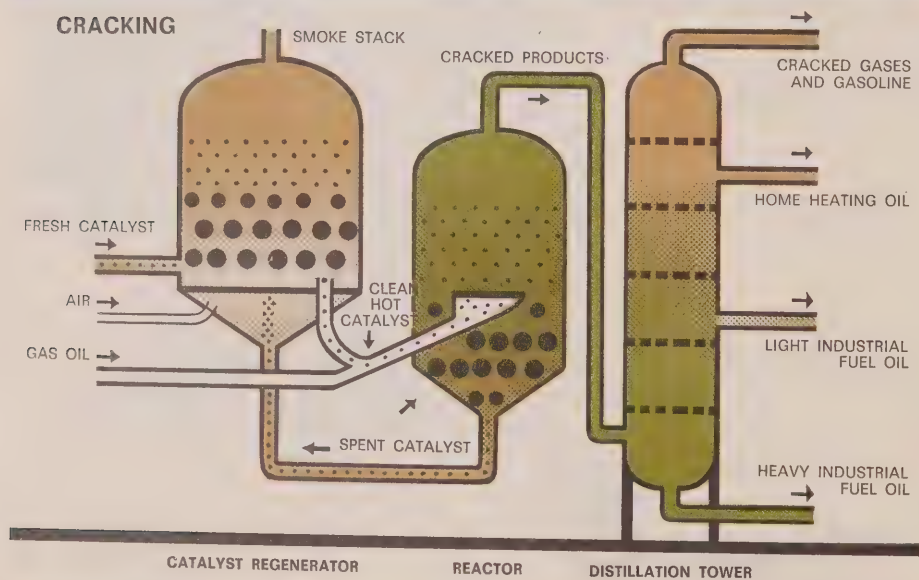
Once petroleum has been produced the crude oil or gas must be transported to a refinery or to the consumer. On water, large ocean going vessels carry the crude oils from the Middle East and Venezuela to the Montreal refineries while Canadian produced propane is transported from Vancouver to Japan. On land, railway tank cars and tank trucks are used to transport crude oil and where long distances are involved, the most efficient and economical method is to use pipelines.



DISTILLATION



CRACKING



Most of the crude oil for Ontario's refineries in Sarnia and along Lake Ontario is transported from Western Canada by a large diameter 2,000-mile-long pipeline. Ontario-produced crude, because of the close proximity to the refineries, is gathered by pipelines in the field but is transported to the refineries by tank truck.

Natural gas is piped to Ontario from Western Canada and the United States in pipelines of up to 36 inches in diameter. To deliver this gas to the Ontario consumer, a large province-wide network of smaller transmission and distribution pipelines has been constructed and buried. Through this network, a continuous supply of gas is quietly and efficiently supplied to the consumer in many cities and towns in Southern Ontario.

REFINING

Crude oil as it comes from the reservoir is a mixture of thousands of hydrocarbon compounds. At the refinery, the crude oil is broken down into nearly 700 different constituents from which thousands of products are made, including lubricants, soaps, plastics, paints and cosmetics.

Through separation, conversion, treating and blending, the crude oil is transformed into its numerous constituents.

SEPARATION

Separation is a process of distillation carried out in tall fractionating towers. The various molecules are separated by heating the crude in a furnace and piping it to the fractionating tower where most of it vapourizes. The vapours which condense at the lowest temperature, settle out at the top of the tower and those which condense at higher temperatures, will settle out at the bottom. A system of trays throughout the column collect the various condensed products which are then drawn off at successive levels. The highly volatile gasolines collect at the top while the heavier asphaltic residues remain at the bottom.

CONVERSION

The next operation in the refining process is "cracking". In this step, the fractions from the distillation process are transformed into useful products or are improved in quality. A

fraction from the distillation process is heated under pressure, and the particular molecules are cracked or broken down into smaller molecules. Modern refineries make additional use of catalysts in preference to straight thermal cracking to produce a better quality product.

The internal combustion engine of today's automobile requires more powerful gasolines. To produce these higher grade gasolines, further refining is necessary. Through "reforming" and "polymerization" the shape of the molecules is changed in the presence of certain catalysts to form more powerful and higher quality products. During reforming, distilled gasolines are heated and passed through a platinum catalyst. In polymerization, the opposite of cracking, small molecules are joined together to form larger molecules.

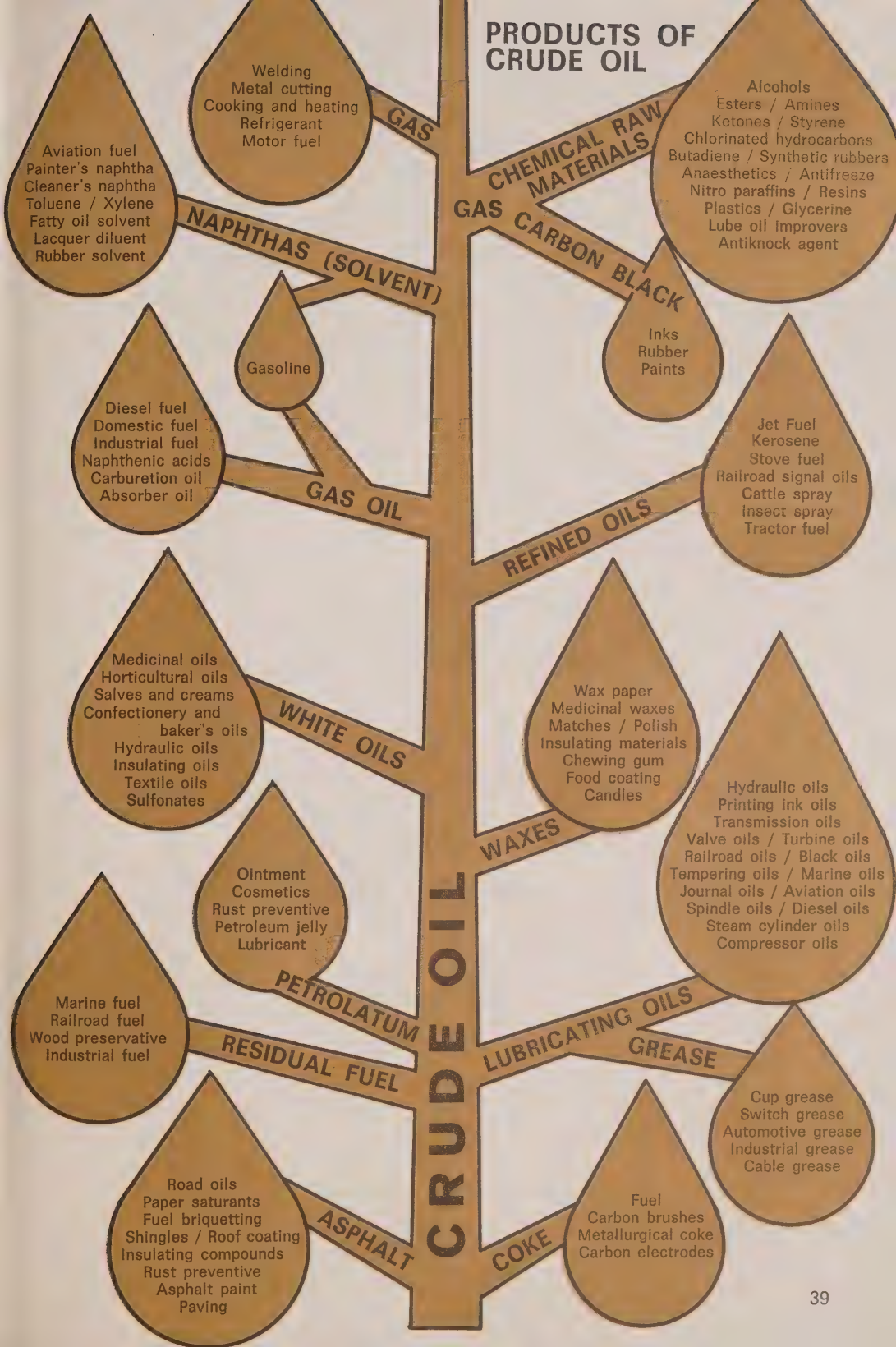
TREATING AND BLENDING

After most refining processes, the various products formed often contain odours, impurities, or certain corrosive elements. These unwanted factions are then removed by "treating" — a process of passing the refined product through certain solutions such as lye and water.

"Blending" is another operation which involves the mixing of certain petroleum factions — creating a final product with better performance characteristics. Gasolines, for example, are blended according to the use for which they are intended, as in automobile or aircraft engines. Blended fuels are further improved by the addition of anti-knock and other inhibitor qualities.

Each of the many geologists, geophysicists, engineers, drillers, oil and gas movers and oil refiners play an equally important role in the efficient and useful development of our oil and gas resources.

It is, however, the oil refinery processes which represent the final step in providing the many commodities vital to the comfort and convenience of the people of Ontario and Canada.





IMPERIAL OIL REFINERY
SARNIA, ONTARIO



Laws governing the regulation of oil and gas production have generally been referred to as conservation laws, although the objectives of the earlier regulations were different than those of today. Formerly, the chief objectives were to protect persons and properties from injury caused by oil and gas and to safeguard the operation of individual wells. Abandoned wells had to be properly plugged, not primarily to conserve anything but to prevent damage to persons and properties in the vicinity.

As the important role of petroleum came to be appreciated and as the knowledge and understanding of its nature and behaviour developed, waste of oil and gas that formerly had been viewed with indifference, became intolerable. Regulations were soon introduced both to prevent waste of oil and gas, and to protect and insure that each landowner in an oil or gas pool received his proper and just share.

Throughout the last thirty years, a constant evolution of engineering practice and legislative control has continued as the knowledge of the efficient exploitation of oil and gas increased.

In Ontario, the Department of Energy and Resources Management is entrusted with the responsibility of regulating the various exploration, drilling and production operations throughout the Province. With a staff of geologists, engineers and inspectors, the Government is able to ensure the proper, safe and efficient development of the Province's oil and gas resources as well as providing industry with technical and professional assistance.

The Ontario industry has operated successfully for over 100 years and present indications are that the Province is continuing to attract companies — both large and small. The number of successful wells drilled compared to dry holes remains encouraging from year to year, and will undoubtedly improve as greater use is made of new exploratory tools and techniques.

Through the availability of Government geological and engineering reports and the Department's computer mapping system, industry is encouraged to explore for and develop Ontario's petroleum resources.

The accessibility of markets, the excellent acreage potential, the forecast of substantial gas reserves in Lake Erie, and the potential of the Hudson Bay Lowland, all offer promise and may well have significant effects on the Provincial economy in the years ahead.

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OIL FIELD . . .



GAS FIELD . . .



